THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

MARCH, 1888.

Thou Lord in the beginning hast laid the foundation of the earth and the heavens are the works of thy hands.

CONTENTS:

ARTICLES:— PAGE

The Computation of Clock Corrections.—PROFESSOR FRANK H. BIGELOW, Racine College 97
Distance and Constitution of the Sun.—THE EDITOR 100
The Distribution of the Stars.—W. H. S. MONCK, Dublin Ireland 105
Good Astronomical Telescopes.—SIR HOWARD GRUBB 106

FOR STUDENTS AND YOUNG OBSERVERS:—

Drawing the Planets 112
The Planets for March.—Occultations Visible at Washington.—Phases of the Moon.—Great Red Spot on Jupiter.—Minima of Algol.—Phenomena of Jupiter's Satellites.—New Minor Planet.—Total Solar Eclipse of 1887.—Period of Algol 114–118

EDITORIAL NOTES:

A New Comet.—Elements of Comet 1886 IX.—Professor G. E. Curtis.—Publications of Lick Observatory.—Cincinnati Zone Catalogue.—Lunar Eclipse at St. Paul.—Fine Views of Saturn.—Total Solar Eclipse, Jan. 1, 1889.—Sun Spots and Auroræ.—Errata.—National Academy of Sciences.—The New Spectroscope of Lick Observatory.—Lunar Eclipse at Baltimore.—Comet 1887 IV (Barnard May 12).—Professor Mary W. Whitney.—Astronomical Observatory for Bucknell University.—Pulkowa Observatory.—Solar Parallax.—New Astronomical Observatory.—Pons-Brooks Comet 118–127

BOOK NOTICES:—

Astronomy for Amateurs, Edited by JOHN A. WESTWOOD OLIVER. Illustrated. Published by Messrs. Longman, Green & Co., London; and New York, 15 East Sixteenth Street 127
The Essentials of Plane and Spherical Trigonometry, By WEBSTER WELLS, S. B. Published by Messrs. Leach, Shewell & Sanborn, Boston and New York 128

The Messenger will be published monthly except for July and August.

Subscription Price per year (ten numbers), $2.

Communications should be addressed to the Editor, Northfield, Minn.

NORTHFIELD, MINN.:

CARLETON COLLEGE OBSERVATORY.

Entered at the Post Office at Northfield, Minn., and admitted for transmission through the mails at second class rates.

J. A. BRASHEAR,

ALLEGHENY, PA.,

MANUFACTURER OF

REFRACTING TELESCOPES

Silvered Glass Reflecting Telescopes,

Objectives and Silvered Glass Specula

OF THE HIGHEST EXCELLENCE.

Plane Mirrors of Speculum Metal or Glass for all purposes of Scientific Research.

Parallel Plates, Prisms of Glass, Quartz, or Rock Salt, with surfaces warranted flat.

Eye Pieces of all kinds, including our Improved Polarizing Eye Piece for Solar observations, the Airy Wide Field for Comet Work, and Solid Eye Pieces for high powers.

Diffraction Gratings ruled on Prof. Rowland's Engine from one to six inches diameter, and ruled with 14,000 to 75,000 lines.

Spectroscopes of all kinds, including Telespectroscopes and Concave Grating Spectroscopes with photographic attachment.

"Comet Sweepers" of our own design, giving ease and comfort in observation, the observer always looking in a horizontal direction, with the eye piece at the same height; Micrometers, Driving Clocks, Heliostats, Siderostats, General and Special Optical Apparatus.

Photographs furnished on application.

XUM

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 7, No. 3. MARCH, 1888. WHOLE No. 63.

THE COMPUTATION OF CLOCK CORRECTIONS.

PROFESSOR FRANK H. BIGELOW, RACINE COLLEGE.

For the MESSENGER.

The determination of the correction Δt and rate μ of a standard astronomical clock becomes a matter of practical experience, rather than that of theoretical method, in the daily work of an observatory. So much refined skill has entered into the construction of the clock, that an observer often feels the instrument is more trustworthy than the man who is the medium of comparison between the time of the stars and the time keeper. In spite of all the care of the computer in the elimination of instrumental errors, there always remains a margin where the exercise of an arbitrary judgment must intervene to decide upon the adopted result.

Let us confine our attention to time-stars near the equator and suppose that every precaution is practiced in the determination of the *c. m. n.* in Bessel's formula, or the A. B. C. in Mayer's formula, there yet remains a series of residual Δt's varying in magnitude as much as two-hundredths of a second. It may be safely asserted that where the observations run throughout the year, the resultant right ascensions of the stars' places will range over about fifteen-hundredths of a second, under favorable circumstances. It was my allotted duty at the Cordoba Observatory to discuss the time corrections, and there were passed in review hundreds of nights and thousands of time-star observations, so that my opinion keeps in view this experience. Three of the years at least—1881, '82 '83, were devoted to this subject of time-stars, while the reductions of the zones and catalogues were in such a condition as to render a further accumulation of circle observations undesirable. Here was an opportunity if ever to reduce all errors to a minimum, as the list comprised for the most part Almanac stars, and the observers

or computers were all men long practiced in this work. An evening's observations took in, say six circumpolars and fifteen time-stars. There were a multitude of very accordant results, but likewise divergencies from the arithmetical mean all the way up to six or eight-hundredths of a second, so that it was fair to allow a range of fifteen-hundredths for unavoidable inaccuracies and yet regard the work as standard in every respect.

It is important to decide upon the best method of dealing with this troublesome margin, since all imperfections here go over into the catalogues, or are eliminated only by increasing the number of observations and taking a mean result. In a discussion on "The Rejection of Discordant Observations,"* Professor Asaph Hall criticises the various mathematical methods, and concludes as follows: "The question occurs whether there is any advantage in the discussion of observations by means of these rules over the judgment of an experienced investigator. I think the reply must be negative. For most cases of discordance that occur in practical astronomy the judgment of an experienced astronomer will be better than any arbitrary rule." There are two general methods of dealing with the observations, the first by reducing the several Δt's to one epoch assuming some clock rate for the interval, and by "least squares" obtaining the most probable correction to rectify this mean Δt and arbitrary p; the second by plotting the several Δt's on square paper, and drawing some representative line through them which is supposed to show the action of the clock. To the first it should be objected that it avoids a use of judgment, presuming that there was a mathematical uniformity of running in the clock, and thus putting all the burden of error on the observations; and again it does not admit the detection of temporary or accidental changes due to lack of compensation under temperature strains, not of the really poor individual observations that necessarily occur. Good and bad are counted as of equal weight in the resultant values, nor is there any attempt to distinguish between them. The graphic method on the other hand does allow a complete inspection of all the incidents attending the night's work, since it lies in a picture before the eye. But it has the practical difficulty, which fol-

* SIDEREAL MESSENGER, November, 1887.

lows from our premise that variations up to fifteen-hundredths of a second do occur, namely, that it is possible to draw several plausible lines or curves through the scattering points—higher or lower or more or less inclined—and that the practical judgment is puzzled which to select. In case there are two observers, as happens when the work continues six or seven hours, the trouble is increased by the necessity of paying attention to the personal equation. All the judgment needs is some clue to the general truth involved in any instance, in order to discover it exactly, and it is the purpose of this paper to offer a suggestion on this point.

I can best produce the idea by indicating the plan pursued at Cordoba. The Δt and ρ of each night were determined graphically in accordance with the best judgment of the occasion, and afterwards these resultant star places reduced to the beginning of the respective years were collected in long ledgers, containing generally about 16,000 observations annually, and in one instance 27,000. This proceeded from 1873 to 1880, but after 1880 all the computations were revised throughout as to the instrumental and time corrections. As a preliminary each night's work was inspected in the ledger, which implied the comparison of over a hundred star-places with the entries of the same star occurring in other nights and years. It was done only roughly and the variety of circumstance entering into the facts before one was so wide as to forbid any collusion of evidence, so that the information gained could be used to detect the tendency of errors in the original computation. It was laborious and involved much readjustment of figures, but it was a sound system of successive approximation, such as astronomy practices in all departments and is in fact the only approach we have to the ultimate truth in human knowledge.

Besides becoming able to exclude the clearly wrong assumptions of the instrumental errors previously made, and seen to be such with surprising vigor of conviction under the new light, it was perceived that there was a strong tendency to readjust the clock rate of the evening to close agreement with the daily rate. From this it may be argued that the clocks have already surpassed the accuracy of observations, and that further skill in this direction is not necessary. The accidental changes of the clocks should be

less discussed, and that of the physical condition of observers more. A second lesson may be learned that a revision of computations by practical judgment is more essential to good results than further improvements in instruments and their use; that this can be done in some degree by an intro-comparison of first computations when they extend over long periods of time, and that consequently the practice of publishing the annual volumes as independent of each other is prejudicial to the highest accuracy of astronomy, since the material is put forth before it has furnished its highest truth. One other conclusion may be ventured, that there is a margin of one-seventh of a second of time that no skill is apparently capable of removing, which must be due to the physico-nervous constitution of observers. It is the measure of the time over which the consciousness and will have only indirect control. The only remedy is to remove the observer wholly, and introduce the electric spark and the sensitive photographic paper in place of the chronograph and human eye. A contrivance attached to the eye end of the telescope, having a rotating and advancing barrel with sensitive paper whereon the emergent pencil of rays from the star makes a continuous trail, except when crossing a wire, and on which trail an electric spark encased in a dark tube with small hole in a point at the pencil struck every second by the standard clock, furnishes the elements of the solution. The efforts being made to overcome this mechanical difficulty ought to be encouraged in every way, as it is the only hopeful method to secure another progressive step in accurate observations.

RACINE COLLEGE, Jan. 3, 1888.

DISTANCE AND CONSTITUTION OF THE SUN.

THE EDITOR.

So many queries about the solar system, or the members of it, have come recently to the attention of those in charge of this journal from various sources, that it is thought best to make a brief statement of the present state of knowledge that astronomy has of the solar neighborhood in which we live.

Naturally we begin with the sun, and the oldest and most important problem which the study of this body offers is the determination of its distance from the earth in terrestrial units of measure. This distance is important because the knowledge of all the phenomena of all the heavenly bodies, except those of the moon, depend directly or indirectly on its value. The problem of the sun's distance is difficult because the data given for determining it are insufficient to enable the astronomer to apply the principles of trigonometry directly to it. He is, therefore, compelled to use indirect methods of solution which, at best, give only approximations to the true distance, arising chiefly from small errors in observation, which, at the present time, seem unavoidable. A familiar illustration will make our meaning clear. The knowledge we have of the sun's distance depends on the accurate measurement of a small angle formed by drawing two lines from a point at the sun to the extremities of the earth's radius. That angle is called the sun's parallax. Ptolemy thought that this angle was 3′ of arc, but we now know that its value is very near 8.80″ of arc, and that the error of this amount from the true angle probably is not more than 0.02″. To measure this small angle has been the astronomer's great trouble since the time of Aristarchus, and he does not yet know its value accurately. His problem is like that of a surveyor attempting to measure a ball, whose real diameter is one foot, at the distance of 4.4 miles nearly; and unless he can determine the diameter of the ball so that he shall not be uncertain in his measure to the amount of 0.03 of an inch, his work will not add any thing useful to present knowledge.

If we suppose the angle of parallax to be known, the computation of the distance of a celestial body is easy. Multiply earth's radius by 206,265 (seconds of arc in the unit radius), and divide the product by the angle of parallax in seconds of arc. The mean equatorial radius of the earth, as given in Clark's Geodesy, is 3963.3 English miles. The sun's distance for a parallax of 8.78″ would be

$$\frac{206{,}265'' \times 3963.3}{8.78''} = 93{,}108{,}000 \text{ miles.}$$

For parallax of 8.80″ = 92,897,000 miles.
For parallax of 8.82″ = 92,686,000 miles.

The range of error in parallax, as here given, is 0.04″, and the change of the distance of the sun in allowing for this error is nearly half a million of miles. If 8.80″ be the assumed parallax, with ± 0.02″ as probable error, then the uncertainty of the sun's distance is still nearly a quarter of a million of miles.

So far astronomers are pretty generally agreed, unless it be in the value of the earth's radius used above. In his excellent work, entitled "The Sun," we notice that Professor Young gives 3,962.72 English miles as the "latest and most reliable determination" (page 22), while he seems to use, Bessel's value of 3,962.80 in obtaining 92,885,000. This may be because the last named value is still in most general use, though less accurate undoubtedly than that of Clarke.

Since the transit of Venus, of 1874, the determination of the solar parallax has not been very much improved. The transit of 1882, so far as known, has given surprisingly discordant results, and probably they will be of very little service in improving our knowledge of the distance of the sun. In the midst of all this uncertainty of late work, in ordinary methods two ways of studying the problem show results almost exactly alike. They are obtained from late improved measures of the velocity of light, and from measures by the heliometer. The parallax from these sources is 8.794″. The Brazilian result of transit of Venus for 1882, by Wolf and André, recently published, make the parallax 8.808″. The American reductions for the last transit are not yet completed.

From the above brief statement of results, it seems that the value of the solar parallax is likely to be a trifle under 8.80″, rather than above it, making the distance of the sun probably very near 93,000,000 miles.

The next most important problem pertaining to the sun is its constitution, which is usually considered under four heads:

1. The central portion, thought to be made up chiefly of intensely heated gases;

2. That part which is seen by the aid of the telescope, called the photosphere, consisting of a "shell of luminous clouds formed by the cooling and condensation of the condensible vapors at the surface where exposed to the cold of outer space" (Young);

3. Outside of the photosphere is a shallow stratum, called the chromosphere, "composed mainly of uncondensible gases (conspicuously hydrogen) left behind by the formation of the photospheric clouds, and bearing something the same relation to them that the oxygen and nitrogen of our own atmosphere do to our own clouds" (Young); and,

4. The corona, which is the beautiful halo seen, with the naked eye, outside of all, during the time of a total eclipse of the sun. This curious halo with all its streamers and rifts is thought to be composed chiefly of an incandescent material, in a far more attenuated state than that of hydrogen, the rarest gas known, because it yields freely in the spectroscope a certain line, 1474 K, which most agree can mean nothing else, although no one knows what the gas or metallic vapor is. Hydrogen is also found in the corona extending to the height of 600,000 miles above the photosphere, and possibly 1,200,000 miles. Suspended in this mixture of vapors and "falling into, or projected from, the sun is a large quantity of solid or liquid material, which is at such a temperature as to be self-luminous. It is this which yields the continuous spectrum, free from dark lines.

Besides these components in the outer envelope, there is present matter which reflects or diffuses light much as our own atmosphere does.

To this is attributed the partial radial polarization of the corona. The streamers and rifts indicate matter repelled, in various quantities, from the sun by forces which may be electrical." (Hastings.)

These are the views advanced by astronomers and physicists, as theories or working hypotheses, until something better or more certain can be known. They are not held as facts by any, because of insufficient proof to establish them as such, and because there are very grave objections to some of them which are at present unanswerable.

For example, the spectroscope shows that the gaseous pressure at the limit of the chromosphere is very small, although that is at the base of an atmosphere from 600,000 to 1,200,000 miles deep, and under the influence of a force of gravity more than twenty-seven times as great as that in action at the surface of the earth.

Optically the atmosphere of the earth ceases at a height

of forty-five miles, but bodies at twice that altitude, moving at the rate of twenty-seven miles per second, meet resistance of air enough to render them incandescent almost instantly. But the evidence seems clear that, far within the corona, the resistance to moving bodies is much less than in our atmosphere at a height of sixty miles. The great comet of 1882 passed through the coronal atmosphere within 300,000 miles of the sun, with a velocity one hundred and eighty times that of the earth in its orbit. The comet was not stopped, nor destroyed, nor its orbit disturbed, as subsequent observations showed. The same thing was true, so far as known, of the comet of 1843, which passed still nearer the solar surface. These facts are troublesome to explain on the hypothesis of a coronal atmosphere.

Still further: if the sun be surrounded by a gaseous envelope, its density, as aforesaid, ought to diminish from the solar surface outward to its upper limits; but the fact is, the material of 1474 K line always appears in the spectrum of chromosphere, which would seem to indicate, by its place, that it is as much more dense than hydrogen as is magnesium vapor, or even the vapor of iron. But the evidence of the spectroscope makes this 1474 K material far less dense than that of hydrogen, and this is a contradiction that is very troublesome to the student of solar physics.

In studying the polarization of the light of the corona, it is clear that the amount of polarized light reflected from a particle at the surface of the sun is nothing, "because the luminous source there is a surface with an angular subtense of 180°;" hence polarization of the corona near the limb of the moon ought to be small, farther away, larger. But observation shows that the contrary is true, *i. e.*, the per cent of polarized light increases as the corona is observed nearer the limb of the moon during totality.

These are a few of the difficult questions that stand in the way of accepting the foregoing theories as facts pertaining to, or well grounded knowledge of, the constitution of the sun. They are by no means all, or possibly the most important ones. They are certainly among those that are receiving very general attention at the hands of physicists at the present time.

More particular discussions of the photosphere and the

chromosphere of the sun will be considered next time, by the aid of such illustrations as may be procured, for the sake of making the meaning of certain phases of opinion clearer than would be possible without them.

(TO BE CONTINUED.)

THE DISTRIBUTION OF THE STARS.

W. H. S. MONCK, DUBLIN, IRELAND.

For the MESSENGER.

I fear my article on this subject contains a serious oversight which vitiates many of my results, though the new ones derived from the correction may prove interesting to your readers. I was, of course, correct in saying that on the hypothesis of uniform distribution the number of stars which would be cut by, "or lie close to," the surface of any sphere drawn at random round the earth (or sun) as centre would be proportional to the surface, but I tacitly assumed that a star of the 5.1 magnitude (for example) would lie as close to the sphere corresponding to 5.0 magnitude as a star of the 4.1 magnitude would to the sphere corresponding to 4.0 magnitude. This (as some of your able readers will probably have pointed out before this letter reaches you) is not the case.

In fact let r_1, r_2, r_3, r_4 be the radii corresponding to the magnitudes 4.0, 4.1, 5.0 and 5.1 respectively, then if the distribution be uniform the number of stars lying between 4.0 and 4.1 will be to the number lying between 5.0 and 5.1 as $r_2^3 - r_1^3$ to $r_4^3 - r_3^3$, or as $(r_2 - r_1)(r_1^2 + r_1 r_2 + r_2^2)$ to $(r_4 - r_3)(r_4^2 + r_4 r_3 + r_3^2)$. But it is easily shown that $\frac{r_4^2 + r_3 r_4 + r_3^2}{r_1^2 + r_1 r_2 + r_2^2} = 2.512$, and therefore the ratio is not 2.512, but $\frac{r_4 - r_3}{r_2 - r_1} \times 2.512$; and since r_4 is to r_3 as r_1 to r_2 (as the change in the intensity of the light proves), we may write this $\frac{kr_3}{kr_1} \times 2.512$, or $\frac{r_3}{r_1} \times 2.512$. But the intensity of the light being inversely as the square of the distance, we get $\frac{r_3}{r_1} = \sqrt{(2.512)}$, and the ratio between the total numbers of stars is (on the hypothesis of uniformity) not 2.512 to 1, but $\sqrt{(2.512)^3}$ to 1 or 3.981 to 1.

Comparing this theoretical result with the figures given by me, it will appear that, with perhaps one or two fluctuations, the number of stars of any magnitude below the second, is always *less* than it would be if the distribution was uniform, the deficiency of stars becoming greater as we descend to lower and lower magnitudes (though the *rate* of thinning appears to diminish). Therefore, *assuming that no light is lost in transmission*, we are traveling through a rich star region which is surrounded by a poorer one; and we are most probably situated *in* the Galaxy, the rich star region to which we belong extending to a considerable distance only in the directions in which the Galaxy extends. I confess, however, that I am more disposed to adopt the theory of a loss of light, whether the ether itself absorbs light, or whether (as seems more probable) a portion of the starlight is intercepted by meteor flights or nebulæ. A particular law of absorption would give results almost identical with those which I originally arrived at, but in the absence of any evidence for such a law I can no longer regard them as shown to be probable.

January 28th, 1888.

GOOD ASTRONOMICAL TELESCOPES.

SIR HOWARD GRUBB.*

A good astronomical telescope, even of small size, is an expensive luxury, and its purchase should not be entered upon without due consideration of the suitability and adaptability of the various forms and constructions to the conditions and surroundings of the intending user.

It is curious to note how differently different people go about starting an astronomical observatory. Some take upon themselves to decide on all points without any previous personal experience whatever, or without consulting any friendly expert; the result being that the instrument, having done its duty as an instructor (*i. e.*, an instructor of the shortcomings of astronomical instruments), finds its way into the market, as a second-hand instrument, in a year or so. Some, again, solicit the advice of their astro-

* From "Astronomy for Amateurs," 1888.

nomical friends all round, but as each of those friends has probably some particular line of work or some particular study most prominently before him (to which he thinks all others should be made subservient), the advice he receives is generally rather perplexing, and if attempted to be followed in its entirety, likely to lead to the production of a kind of second-rate Admiral Crichton of an instrument, suitable to a certain degree for all classes of work but first-rate for none. Others, again, take perhaps the advice of one experienced friend, and this is much better, for if that friend be a man who has done good work, it is likely that he will become possessed of an instrument suitable at least for that one particular line. The worst of all cases and the most unsatisfactory for the instrument maker, is that of the would-be astronomer who comes and says, "Now I want a telescope, and I want to do some astronomical work. I don't know what that work is to be, and even if I did, I don't know what form of instrument would be best suited for it; but please do the best you can for me for so much." The instrument maker is probably unacquainted with the purchaser's position, surroundings, taste, and qualifications, etc.; in fact, every factor which should be taken into account in deciding such a question; ten to one, he, with the best intentions, advises some unfortunate course, which the amateur gets thoroughly sick of very shortly, and the result is dissatisfaction on all sides.

If the amateur would take the trouble to consult a few good reliable works on the subject, so as to be able to take an intelligent view of the subject, he will find that after a little he will be able to communicate to the instrument maker his special desires, and discuss with him the applicability of the various forms to his special purpose. It is with a view to aid amateurs in this matter that the present remarks are offered.

The Mounting. In the present day it may be assumed that any one who possesses an astronomical telescope, except of the smallest size, will not think of mounting it on any other form than the equatorial. It is the only form in which the heavenly bodies can be followed by a uniform motion of the instrument around one axis. If the axis be placed in any other position, it is not possible to follow the object without

a double motion, and that varying in a most complicated manner; nor is it possible to apply clock-work, except with the most complicated contrivances. The superiority of the equatorials for astronomical purposes has always been recognized since their first introduction, but up to late years it was not possible to procure these, except of great complexity and corresponding expense. Now, however, when really practical little tools suitable for mounting small instruments can be obtained at prices quite as low as the simplest alt-azimuth, that difficulty is removed, and no one probably will think in the future of using anything but an equatorial for astronomical purposes. [There are cases, however, in which the alt-azimuth (provided with circles) has its advantages. One of the most successful discoverers of comets at the present time uses such a mounting, as more suited to that particular class of work.] Of the various forms of equatorials, also, it will hardly be necessary to treat in this chapter, as it is only intended that the remarks here made should have reference to refractors up to 8″ in diameter, and reflectors to 12 or 25, and there is for these sizes really but one type of equatorial usually used by the instrument makers of this country, *i. e.*, the so-called (but misnamed) German form. The other two distinctive types—the old English divided polar axis (such as the Greenwich refractor) and the biforked polar axis (in which the telescope is swung between a pair of jaws forming a prolongation of polar axis above upper bearing) need not be discussed, as they are not practically procurable.

The first and most important point to look to is the stability of the instrument. This depends on various conditions. Suppose the foundation, or pillars, or whatever the instrument be mounted on, to be sufficiently firm, the stability depends on the porper proportioning and construction of the axes and their bearings, and the general strength of the body or frame-work. It may be asked what size and length should the axes be in proportion to the diameter of objective or special size or form of telescope, etc. This is a question it would be almost impossible to answer, as so much depends on the construction and arrangement of the parts.

A rough, but fair test of the stability, however, may be

made thus: Turn the telescope to a star (a polar star preferable if there be no clock-work), and put a high power on telescope, say 200 for a 3-inch objective, and try if you can focus satisfactorily and comfortably without causing the image to dance about in the field. If the image is unsteady in the field, it will be impossible to focus satisfactorily, and the stand is defective.

It may be asked, how am I to specify to an instrument maker the degree of stability necessary, or how am I to know before hand that the instrument he recommends me will have the requisite stability? To this the best answer is: Go to an instrument maker of repute, and tell him you want an instrument of such size for star-gazing, or for micrometrical work or spectroscopic work, as the case may be, and you may be perfectly sure that he will not risk his reputation by recommending you anything unsuitable.

Quite apart from stability there is a certain quality of rigidity which is very desirable. This is generally not so much a matter of mere strength of axes, etc., as of proper construction and arrangement of the clamps and slow motions. Every mounting to carry a 4″ or over refractor ought to be provided with clamps and slow motions in right ascension and declination, and if these be not properly constructed there is want of rigidity and definiteness of position of the instrument.

To test this, point instrument as before on a star, clamp both right ascension and declination: now press finger with a few pounds pressure against side of rack tube, trying it up, down, right and left. On application of each successive pressure the star will be seen to move slightly in the field (for no instrument is absolutely rigid), but on releasing the pressure the image ought to return to almost the same place as before.

The clamping handle should clamp very decidedly and promptly, a quarter turn of handle should suffice to clamp or unclamp, and, when clamped, the telescope should be quite firm and not movable except by considerable force.

The slow motions should work with as little "back lash" or "loss of time" as possible—*i. e.*, after working in one direction, if the handle be reversed the motion of the instrument should respond almost at once to the reversed motion of the handle.

There are several forms of slow motion used. For declination, generally a screw working into a sector, or what is called the German form, a screw bearing directly upon a clamp which is kept in good contact with it by a spring, is suitable for small, light instruments. For right ascension movement, the slow motions are generally either of the form of a tangent screw of some kind, or a differential gearing in clock shaft which, when worked in one direction or other, causes a temporary acceleration or retardation of rate at which clock drives endless screw. Whatever be the form used, if the instrument stands the test given above, it is sufficiently good; but if a differential gearing be used, see that it is of a form in which the additional wheels only come into use when the slow motion handle is turned. Some of the differential slow motion introduce several wheels directly into the clock train; there is no necessity for this, and every wheel added between governors and clock train is a disadvantage.

Another point to be considered about equatorial mounting is its general convenience. Some mountings have inconveniences attending them which are never discovered till they come to be used; but here again it is necessary to trust, to a great extent, to the instrument maker. Any instrument maker of experience has of course had all matters of convenience and inconvenience brought prominently and constantly before him; his business is to grapple with these matters, and they may generally be safely left to him. A few points may, however, be mentioned:

See that the telescope has, to as large extent as possible, circumpolar motion—*i. e.*, that up to as high an altitude as possible the telescope can be allowed to follow a star without requiring reversal when the star passes meridian. In some instruments the clock and other parts of apparatus are so placed that when the telescope has followed the star from E. to meridian, or just a little beyond, it (the telescope) comes against some part of the stand or clock, and the whole instrument has to be reversed to other side of pier, and the observation re-commenced. This is often very vexatious, as it is just the best possible position for observing. There is no difficulty in arranging matters so that any star up to 75° or 80° altitude can be observed without necessary reversal of

instrument. Another convenience resulting from this, that there is thus generally a possibility of a choice of two positions in observing any star up to that altitude, *i.e.*, with telescope E. or W. of Polar axis, if star be near meridian; or above or below Polar axis, if star be E. or W. See also that if motion of telescope is liable to be stopped near meridian by some portions of instrument, that it be not likely to be so stopped by any delicate part, such as clockwork, etc. This is another great convenience.

All clamping handles and slow motion arrangements should be convenient to hand of observer while he is in a position for observing.

Circles should be clearly but not too finely divided. In the smaller instruments, in which accurate determinations of position are rarely wanted, it is a mistake to employ circles too finely divided. It is rarely that the vernier in right ascension circle is ever used; generally the zero point is quite sufficient. Amateurs have not often the means of knowing the time so accurately, or the facility of calculating the refraction so conveniently, that they require to set the right ascension circle nearer than to fifteen seconds of time.

For very small telescopes of simple but efficient construction, some makers use circles printed on paper, which are clearly and easily read, and quite as accurate as the ordinary class of metallic circles on the less expensive stands, and can be replaced when required at a cost of a few pence.

On the better class of instruments various convenient appliances are added by different makers for different purposes.

Readers, by which the circles can be read from eye-end of telescope, etc., these are just so many labor-saving contrivances, very useful and very convenient, but without which it is quite possible to do the very best work.

In equatorial instruments, as well as in most mechanical instruments, there are two totally different classes of "cheap" instruments.

There is the instrument which is cheap because it is inferior in every way, badly designed and constructed and clumsily made. This is dear at any price. But there are also instrumetns sold at low prices by good makers which are cheap; not because they are inferior in any way, but because they have been simplified down, and all unnecessary work and

finsh dispensed with. They do not profess to do as much as the other class of instruments. But what they do they do well, and they can have such additions made to them from time to time as the purchaser may desire.

Except in very small instruments, it is much better that the endless screw driven by clock-work gears into teeth cut on a long radius of sector than into teeth on an entire circle, which must necessarily have a short radius. For any given error in screw or bearings, the effect or motion of insturment will be in the inverse ratio of radius of toothed circle.

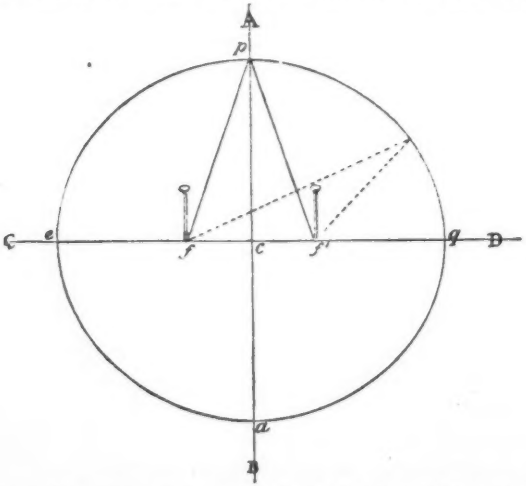
For large equatorials, those 5″ or over, it is better that the clock-screw have a square and not a V thread.

(TO BE CONTINUED.)

FOR STUDENTS AND YOUNG OBSERVERS.

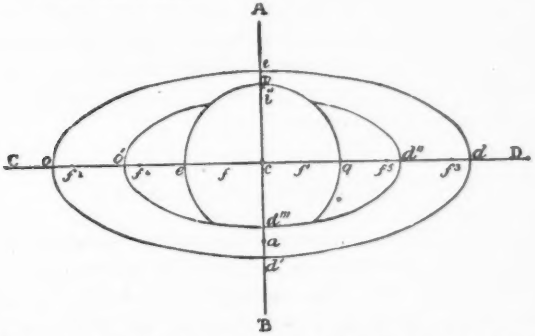
DRAWING THE PLANETS.

Suppose we next try to draw the outline of the planet Jupiter, as seen in a small telescope. The accompanying figure will indicate how this is to be done. For the month of



February the average equatorial diameter of the planet is 37.49″; the polar diameter is found by multiplying the equatorial diameter by .939, or it is directly given in Nautical Almanac. If 17″ = 1 inch, *eq* will equal 2.20 inches.

Then from the centre *c*, where the two diameters cut each other, we take the distance *ce*, or *cq*, in the compasses and placing one leg on *p* or *a*, move them about until the other touches the line *cq* in the points *f* and *f'*. Into these two points, technically called the *foci* of the ellipse, we stick two pins, and round these tie a loop of thread of such length that when stretched tight by a pencil, the point shall touch either *a*, *e*, *p* or *q*. *f p f'* represents this thread in the figure, and if it be kept tightly stretched, as the pencil is carried round, the curve *f e a q* will be the correct elliptical outline of Jupiter to the adopted scale. The accompanying figure is a little larger than the numbers given above call for, being drawn for another date.



The description of the outline of Saturn and his rings only involves a repetition of this process. The successive steps will be understood by a study of the figure below.

The polar diameter of Saturn for the middle of February is a little more than 19″; its equatorial diameter is in the ratio of 1 : 0.895, being therefore 21.3″. If the equatorial diameter be taken as one inch, then 0.895 of one inch will be the polar diameter. Make *e q* one inch, and *p a* 0.895 of an inch, and construct the elliptical outline of the planet precisely as before. Now looking at page 481 of the Nautical Almanac, we find the outer major axis of the ring for February is 46″, and the outer minor axis is 16.08″. These values correspond to *o d* and *i d* respectively. On the same page we find the factor to be multiplied by line *o d* to obtain the major axis of the inner ellipse of the inner ring = 0.66. The minor axis of the inner ellipse of the inner ring is found by multi-

plying its major axis by 0.43, which serves fairly well to indicate the apparent relation of the axis as seen at the present inclination of the rings. Perhaps enough has been said to show how the three ellipses can be drawn and to give some knowledge of the sources of information if the young observer have not the means of measurement connected with his small telescope.

It may be asked if it be advisable to pursue the above methods night after night, or week after week, in the study of the planets. Certainly not; for the outline of Jupiter is very nearly invariable, and Mars and Saturn vary so slowly that one drawing will last for many weeks. If such drawing be transferred to stencil plate, which is inexpensive to cut in outline, it will be of ready use for the observing book from night to night in the study of details. Good observers are known to follow this plan. These suggestions are taken from Capt. Noble's excellent little book entitled "Hours with a Three-inch Telescope."

Interesting Phenomena for March.

Mercury will be at inferior conjunction on March 3, about 4° north of the sun's centre. He will be stationary in right ascension on the 16th; at descending node of his orbit on the 21st; in conjunction with Venus on the 27th; at greatest elongation west 27°49′ on the 30th; and in aphelion on the 31st. The conjunction with Venus would be an interesting phenomenon to observe, since the planets will be only 2′ apart, and in some latitudes the parallax may bring them still closer together; but unfortunately it occurs below the horizon of observers in the United States. During the middle of the month of February Mercury was quite a conspicuous object in the clear western sky of Minnesota an hour after sunset, so that the most casual observer could hardly fail to notice him. During the latter part of March he will be in favorable position for observation in the morning.

Venus will be in conjunction with the moon on the 9th at 3*h* 36*m* P. M., and will be occulted to observers in the South Pacific ocean. She passes this month from Capricorn into Aquarius. Her phase increases from 0.828 to 0.892, while the diameter of her disk decreases from 13.0″ to 11.6″.

Mars is in Virgo, and not in Libra as stated last month, and will be stationary on the morning of the 4th. After that he will slowly retrograde for a couple of months. He will be in conjunction with the moon, south 2°35′ on the 28th at 8.15 P. M. Mars is approaching opposition, and is now in good position for observation. His phase increases during the month from 0.945 to 0.994, and his apparent diameter from 12.4″ to 16.0″.

Jupiter is in the foot of Ophiuchus, almost directly north of Antares (α Scorpii). He will be in conjunction with the moon on the 21st, and after that will slowly retrograde toward β Scorpii. He will be in conjunction with the moon, —3°47′ on the 4th at 4:36 A. M., and again on the 31st at 0.36 P. M., —3°32′.

Saturn still continues to retrograde in the constellation of Cancer until the 30th, when he will be stationary. He will be in conjunction with the moon on the 22d at 9:45 P. M., being then 1°20′ north of the moon's centre. The elevation of the plane of Saturn's rings above the earth will be at its maximum for this year at the end of this month, being 21° 12′ on March 20th. On the same date the major and minor axes of the outer edge of the outer ring will be 43.76″ and 15.83″ respectively. Ordinarily five of the satellites of Saturn may be seen with an eight-inch telescope, the brightest being Titan, the next Japetus, then Rhea, Dione and Tethys, nearly equal in brightness.

Uranus and *Neptune* move so slowly that their change of position from month to month is scarcely noticeable without a telescope. The latter will soon be lost in the advancing sunlight. The former may be observed for several months yet.

NEPTUNE.

	R A.	Decl.	Rises.	Transits.	Sets.
	H. M.		H. M.	H. M.	H. M.
March 5.....	3 42.4	+17°59′	9 28 A. M.	4 46.0 P. M.	12 04 A. M.
15.....	3 43.1	+18 02	8 49 "	4 07.4 "	11 26 P. M.
25.....	3 44.1	+18 06	8 10 "	3 29.0 "	10 48 "

SATURN.

March 5.....	8 09.9	+20 41	1 42 P. M.	9 12.7 P. M.	4 43 A. M.
15.....	8 08.4	+20 46	1 01 "	8 31.9 "	4 03 "
25.....	8 07.7	+20 48	0 20 "	7 51.8 "	3 23 "

URANUS.

March 5.....	13 01.5	− 5 49	8 23 P. M.	2 03.5 A. M.	7 44 A. M.
15.....	13 00.1	− 5 40	7 42 "	1 22.8 "	7 04 "
25.....	12 58.6	− 5 30	7 00 "	12 42.0 "	6 24 "

MARS.

	R. A. H. M.	Decl.	Rises. H. M.	Transits. H. M.	Sets. H. M.
March 5	13 56.2	− 9 02	9 30 P. M.	2 58.1 A. M.	8 26 A. M.
15	13 52.9	− 8 44	8 47 "	2 15.4 "	7 44 "
25	13 44.7	− 8 04	7 57 "	1 28.0 "	6 59 "

JUPITER.

March 6	16 17.0	−20 23	12 40 A. M.	5 18.5 A. M.	9 57 A. M.
16	16 18.5	−20 25	12 02 "	4 40.6 "	9 19 "
25	16 18.6	−20 25	11 23 P. M.	4 01.4 "	8 40 "

VENUS.

March 6	21 06.8	−16 57	5 13 A. M.	10 07.4 A. M.	3 02 P. M.
16	21 55.4	−13 31	5 08 "	10 16.7 "	3 26 "
26	22 82.6	− 9 27	4 58 "	10 24.3 "	3 50 "

MERCURY.

March 6	22 43.6	− 4 26	5 58 A. M.	11 44.1 A. M.	5 30 P. M.
16	22 26.5	− 8 29	5 18 "	10 47.7 "	4 17 "
26	22 44.6	− 9 01	4 59 "	10 26.4 "	3 54 "

OCCULTATIONS VISIBLE AT WASHINGTON.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean Time. H. M.	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. H. M.	EMERSION. Angle f'm N. P't. °	Duration. H. M.
Mar. 5	α Sagittarii	4	13 55	159	14 28	224	0 33
5	15 Sagittarii	5½	14 18	63	15 10	319	0 51
26	b Virginis	5½	10 52	109	12 07	310	1 15
29	ξ^1 Libræ	6	11 30	95	12 36	319	1 06
30	49 Libræ	6	15 16	77	16 23	322	1 07
April 2	33 Sagittarii	6	12 15	126	13 07	249	0 52
2	ξ^2 Sagittarii	3½	14 04	37	14 40	336	0 36

PHASES OF THE MOON.

		Central Time. H. M.
Last Quarter	March 4,	9 25.9 P. M.
New Moon	March 12,	10 21.0 A. M.
First Quarter	March 20,	2 43.4 P. M.
Full Moon	March 27,	4 07.5 P. M.

GREAT RED SPOT ON JUPITER—TIMES WHEN ITS ZERO MERIDIAN PASSES THE CENTRE OF JUPITER'S DISK.

	Central Time. D. H. M.		Central Time. D. H. M.		Central Time. D. H. M.
March	2 5 42.7 A. M.	March	12 3 58.5 A. M.	March	22 2 13.8 A. M.
	3 1 34.0 "		12 11 49.7 P. M.		22 10 05.0 P. M.
	4 7 20.8 "		14 5 36.7 A. M.		24 3 52.0 A. M.
	5 3 12.3 "		15 1 28.0 "		24 11 43.2 P. M.
	5 11 03.7 P. M.		16 7 14.9 "		26 5 30.1 A. M.
	7 4 50.7 A. M.		17 3 06.2 "		27 1 21.3 "
	8 12 41.9 "		17 10 57.4 P. M.		28 7 08.2 "
	9 6 28.8 "		19 4 44.4 A. M.		29 2 59.5 "
	10 2 20.2 "		20 12 35.6 "		29 10 50.6 P. M.
	10 10 11.5 P. M.		21 6 22.6 "		31 4 37.6 A. M.
				April	1 12 28.7 "

MINIMA OF ALGOL (β Persei; R. A. 3h 01m, Decl. +40°31′).

	Central Time. D.	H.	M.			Central Time. D.	H.	M.	
March	3	6	01	P. M.	March	18	2	06	A. M.
	6	2	50	P. M.		20	10	55	P. M.
	9	11	39	A. M.		23	7	44	"
	12	8	28	"		26	4	33	"
	15	5	17	"		29	1	21	"

PHENOMENA OF JUPITER'S SATELLITES.

	Central Time. D.	H.	M.			Central Time. D.	H.	M.		
March	6	2	36	A. M.	I Sh. In.	March	21	3	44	A. M.	I Ec. Dis.
		3	50	"	I Tr. In.		22	12	50	"	I Sh. In.
		4	48	"	I Sh. Eg.			1	58	"	I Tr. In.
		6	02	"	I Tr. Eg.			3	02	"	I Sh. Eg.
	7	12	32	"	III Tr. In.			4	10	"	I Tr. Eg.
		2	05	"	III Tr. Eg.		23	1	29	"	I Oc. Re.
		3	21	"	I Oc. Re.		24	2	18	"	II Ec. Dis.
	8	12	30	"	I Tr. Eg.			11	41	P. M.	III Oc. Re.
		2	51	"	II Sh. In.		25	11	31	"	II Tr. In.
		5	18	"	II Sh. Eg.			11	49	"	II Sh. Eg.
		5	21	"	II Sh. Eg.		26	1	57	A. M.	II Tr. Eg.
	10	2	01	"	II Oc. Re.		29	2	43	"	I Sh. In.
	13	4	28	"	I Sh. In.			3	47	"	I Tr. In.
	14	1	12	"	III Sh. Eg.			4	55	"	I Sh. Eg.
		1	50	"	I Ec. Dis.		30	12	06	"	I Ec. Dis.
		4	22	"	III Tr. In.			3	18	"	I Oc. Re.
	15	12	09	"	I Tr. In.			11	23	P. M.	I Sh. Eg.
		1	09	"	III Sh. Re.		31	12	26	A. M.	I Tr. Eg.
		2	21	"	I Tr. Eg.			4	51	"	II Ec. Dis.
		11	40	P. M.	I Oc. Re.			11	13	P. M.	III Ec. Re.
	16	11	44	"	II Ec. Dis.	April	1	1	50	A. M.	III Oc. Dis.
	17	4	29	A. M.	II Oc. Re.			3	18	"	III Oc. Re.
	21	3	22	"	III Sh. In.						

New Minor Planet (*272*) was discovered by Charlois of Nice, Feb. 4. 4808 G. M. T.; right ascension 10*h* 1*m* 10.8*s*; declination + 19° 20′ 22″. No. (271) discovered by V. Knorre, of Berlin, has been named Penthesilée. No. (269) the last found by Palisa has not yet been named.

Total Solar Eclipse of 1887. The preliminary report (unofficial) of the total Solar Eclipse Expedition of 1887, in charge of Professor David P. Todd, of Amherst College Observatory, has been recently received. That part which pertains to Astronomy for substance has already been reported.

Period of Algol. S. C. Chandler, Jr., of Cambridge, Mass., is making a thorough study of the period of Algol, a portion of his paper having already appeared in the last number of the *Astronomical Journal.* We also notice that Professor Oudemans, of Utrecht, is engaged in deducing new elements of Algol.

EDITORIAL NOTES.

A New Comet was discovered by Sawerthal, Feb. 18.6059, having right ascension $19^h\ 11^m\ 32.85^s$; declination south 56° 03′ 44″; daily motion, 6.9^m east and 1° 15′ north. The nucleus of the comet, at the time of discovery, was of the seventh magnitude in brightness, and well defined. The comet was visible to the naked eye having a tail two degrees long. When first seen, it was in the constellation of the Telescope, and on the first day of March it will be in the south part of Sagittarius, moving, apparently, almost directly towards the sun. At that time it passes the meridian about 3° above the horizon in latitude 45° north, in light, hence not then visible so far north. It promises to be an interesting object on account of size and rapid motion.

Elements of Comet 1886, IX. The following elements were computed from observations made by Professor Frisby at the U. S. Naval observatory, 1886, Oct. 7, Nov. 3, Dec. 1 (see *Astron. Journ.*, vol. vii, pp. 8 and 31):

T 1886, Dec. 16.49674
ω 86° 19′ 54.4″
Ω 137 22 19.9 } Mean eq. 1886.0
i 101 36 25.5
$\log q$ 9.821770
Middle place $d\lambda \cos\beta = -2.9''$
$o - c$ $d\beta = +3.6$

W. C. WINLOCK.

Professor G. E. Curtis, of Washburn College, kindly remembers THE MESSENGER with advance sheets of his report of Lieut. Lockwood's astronomical observations on the north coast of Greenland while connected with the Lady Franklin Bay Expedition, May 1882. These sextant observations were made by Lieut. Lockwood on his sledge journey to Lockwood Island and were reduced by Sargent Israel, astronomer to the expedition, after his return to Fort Conger. Professor Curtis' work has been to review the reductions, correct arithmetical errors and arrange them for publication. As shown by these observations the latitude of the farthest point north reached by Lieut. Lockwood was 83° 24′, the highest on record.

XUM

Publications of Lick Observatory. The first volume of the Publications of the Lick Observatory has been received. Its size is about that of the Cambridge volumes, and it contains 312 pages. It is an exceedingly interesting publication because it gives so much of the detailed history of the great observatory from the first, that has been omitted from nearly all popular articles about it in the past. One of the first things to catch the attention is the report of Professor Newcomb on the result of his trip to Europe in 1875 to confer with the leading men of science in England, France and Germany deemed by him best able to give information as to the probable limit of available size that a refractor could be made; and also to ascertain what optical firms could be prudently entrusted with the construction of such an instrument, larger than any then existing. An abstract of this will be given later.

We were a little disappointed not to find, in this connection or elsewhere in this volume, the report of the committee whose duty it was to make an examination of the optical qualities of the 36-inch lens which was tested last summer at Cambridgeport. It doubtless will be given to the public later.

Then follow the report of S. W. Burnham on the advantages of Mt. Hamilton for an observatory site, and his discoveries and observations while there; the description of the instruments; a history of the work done during the last five years; full meteorological record with interesting summary; a set of twenty tables of reduction for the latitude of Mt. Hamilton, which cover the following points: Transit factors A. B. C. D., transit factors for all B. J. stars with variations of factors with the time, extension of Pulkowa refraction tables to barometer pressure of 25 inches, auxiliary table for computing refractions, zenith distances, parallactic angles, etc., Differential refractions in R. A. and Decl., parallax in R. A. and Decl., hour angles and azimuths in the horizon, zenith distances, interpolating for the Sun's place, diurnal aberration in R. A. and a dozen other tables on kindred subjects useful in general observatory work. The volume indicates a wise and judicious beginning for a work of unexampled range and magnitude in the future.

Cincinnati Zone Catalogue. Publication No. 9 of Cincinnati Observatory, which we have just received, contains the results of a series of zone observations made with a three-inch Buff and Berger transit instrument during the years 1885, 1886 and the first half of 1887, and gives a good example of the work which may be done with an inferior instrument in the hands of an assiduous and careful observer. The region covered by the zones is from declination —18°50′ to —22°20′. Within these limits 4,050 stars have been observed, including nearly all of the stars down to the 8.5 magnitude, and a considerable number of fainter ones. The observations were made by the director of the Observatory, Professor J. G. Porter, assisted until June, 1886, by Mr. H. C. Wilson, the observers taking alternate zones in declination.

The positions of the stars depend upon those of zero stars observed in each zone, differences of right ascension being observed by transits recorded by chronograph and differences of declination by bisections with a micrometer wire. An eye piece magnifying thirty times and giving a field of 50′ diameter was employed. The zones were taken only 15′ apart in declination, so that generally each star was observed three times in different parts of the field of view. Professor Porter gives as the probable error of a single observation, derived from 342 stars chosen at random, $\pm 0.123^s$ and $\pm 1.84''$. A list of 201 zero stars precedes the zone catalogue. The places of these zero stars were taken from the most recent catalogues, none depending on observations made earlier than 1875, excepting a few taken from the Greenwich nine-year catalogue.

The arrangement of the catalogue is convenient and compact, giving in a single line on one page the reference number, magnitude, right ascension and declination for 1885.0, precession, number and epoch of observations in both R. A. and Decl., and references to earlier catalogues. Professor Porter has done a valuable and laborious work in comparing his places of the stars with those found in the earlier catalogues, and, as a result, has appended to his catalogue a considerable list of errata in Lalande, Oeltzens-Argelander and Lamont's Zones, and also a list of seventy-five proper motion stars, most of which are new. It is interesting to notice that more than half of these are from 8. to 9. magnitude.

XUM

Lunar Eclipse at St. Paul. Notwithstanding the unfavorable weather in this vicinity on the 28th ult., two of the phases of the lunar eclipse of that date were visible here; these phases being "middle of eclipse" and "ending of totality." At this place the moon rose at 5:10 P. M., central time, and as the "middle of eclipse" occurred ten minutes thereafter, the moon was at an altitude of only a little more than 1° at the time of this phase. Owing to an obstructed horizon, I was unable to see it until about thirty minutes after the time of the greatest obscuration. The moon had then attained an altitude of nearly 5°, and notwithstanding the fact that it was wholly immersed in the earth's shadow, the lunar disc was very distinctly visible and shone with a dull red light; this light was bright enough to render the irregularities of the moon's surface very apparent, the lunar elevations being noticeably bright, while the lowest portions were only faintly discernible.

Although the "coppery line" on the disc of the totally eclipsed moon is not a rare phenomenon, being noticeable, to a greater or lesser extent, at, probably, every total lunar eclipse, yet its intensity on this occasion, when the moon was so near the horizon and the twilight was considerable, seems to me worthy of remark. If there had been a clear view of the horizon, I think that the totally eclipsed moon would have been visible to me at the moment of its rising. The striking aspect of this phenomenon was probably due to an extraordinary translucency of the atmosphere at all points on the earth in the vicinity of which the surface of the "cone of the shadow" was tangent to the surface of our globe; for the phenomenon is caused simply by the reflection, from the lunar disc, of those rays of sunlight which have been reflected and refracted and thrown thereon by their passage through a zone of atmosphere surrounding the earth in the vicinity of all the points of tangency.

The "ending of totality" was observed at 6:09 P. M., at which time the moon's limb appeared as a pretty well defined bright point, the penumbra being not particularly noticeable. This point developed rapidly into a beautiful crescent, which, in the course of about five minutes, attained the dimensions of the illumined portion of the moon when the latter is between two and three days old. About this

time, when the area of the luminous crescent was to the area of the unillumined part of the lunar disc, as one to eleven, the "coppery line" disappeared, probably by reason of the irradiation from the crescent, just as the "ashy light" near the time of the new moon disappears as the moon's age increases. This disappearance of the "coppery line" was probably hastened by meteorologic causes, for shortly afterward clouds intervened, quickly obscuring the lunar disc, and precluding any further observations. S. J. CORRIGAN.

St. Paul, Minn., Feb. 14, 1888.

Five Views of Saturn. On Wednesday evening, February 1st, having just shown a party of visitors through the Chabot Observatory, I was joined by Mr. E. E. Barnard, of the Lick Observatory, and Mr. Charles Burckhalter, my colleague at the Chabot, and as the night had appeared to be exceptionally fine we all went into the dome to study Saturn. The eight and one-half-inch Clark equatorial was used with powers ranging from 200 to 450 diameters, with fine results, and every detail shown on Trouvelot's drawing in the Harvard collection was easily made out. The "dusky ring" was distinct all around, and decidedly brighter at the *following* ansa. The shadow of the planet was seen on *both sides* of the ball, (Saturn being near opposition), that on the *preceding* side amounting only to the merest black dot, exactly at the "Cassini" division. The markings on the ball were beautifully distinct, and the cold steel tinge at the south pole very perceptible. But the most interesting detail to all of us was the undoubted visibility of the "Encke division." It was very plainly seen at the *preceding* ansa, and only glimpsed at the *following*; but was traced for some little distance at either side and gave the impression of being—not an absolute division, like the well-known separation between the A and B rings,—but more like a marking or "belt" on the surface. And it was very decidedly not in the centre of the A ring, but at the most, only one-third of the distance from the outside. The whole view was grand.

On the succeeding evening I found the atmosphere not quite so good, and all these features less remarkable; the "Encke division" was not well seen. The dusky ring was on this occasion decidedly brighter at the *preceding* ansa.

Oakland, Cal., Feb. 3, 1888. CHAS. B. HILL.

Total Solar Eclipse, Jan. 1, 1889. The belt of totality in the solar eclipse on January 1, next, traverses California, where, at that season, favorable atmospheric conditions for observations may be anticipated with some degree of confidence.

The central line meets the American coast at Point Arena, traversing the state of California in the direction of Pilot Peak, which is also close upon the central eclipse. At Point Arena totality commences at 1*h* 30*m* 33*s* local mean time, or at 1*h* 45*m* 13*s* Pacific standard time, and continues 2*m* 3*s* according to the elements of the *Nautical Almanac*, the sun at an altitude of 25°. At Pilot Peak totality commences at 1*h* 45*m* 54*s*, local mean time, or at 1*h* 49*m* 46*s* Pacific standard time and continues 1*m* 57*s*, with the sun at an altitude of 23°. Between these points the central eclipse crosses the track of the Central Pacific railroad, or rather branches of that line, north of Colusa. Probably any observers proceeding from Europe for the observation of this phenomenon will not care to locate themselves east of the Sierra Nevada, the duration of totality of course diminishing with decreasing westerly longitude, and the sun's altitude also becoming less, so that in 105° 29′ W. and 46° 39′ N., close on the central line, the total eclipse begins at 3*h* 4*m* 14*s* local mean time, and continues 1*m* 25*s*, with the sun at an altitude of only 9°. The main line of the Central Pacific appears to be again crossed near Oreana.

At Mendocino totality commences at 1*h* 29*m* 47*s* local mean time, and continues 1*m* 45*s*. At San Francisco and its suburbs, Alameda, Oakland and Berkeley (the seat of the University of California, now presided over by our associate Professor Holden), the eclipse, though very large will not be total. At San Francisco the magnitude is 0.987, and it is to be regretted that the Lick Observatory on Mount Hamilton is not within the shadow; the greatest eclipse there at 1*h* 45*m* local mean time, magnitude 0.974.

J. R. HIND, in *Monthly Notices*.

An interesting article on the photographic outfit for astronomical work, at Harvard College Observatory, appears in the Boston Daily *Globe* (Feb. 12), in which are given cuts of the new instruments, buildings, and a general view of the Observatory grounds.

Sun Spots and Auroræ. On the 13th of December at 1:30 P. M. standard time of 120 meridian, I observed with the 6⅛-inch equatorial refractor of this observatory, using a sun prism and power of 40, a large spot south of the equator about one 20th of the diameter of the sun from his west limb. It was new to me, but the weather had been unfavorable for several days previously. The spot exhibited great activity. The night of the 13th showed a brilliant auroral display in the northeast. It lasted from 9:30 P. M. until 2 A. M. This is an unusual phenomenon in this region of the country. On the morning of December 14, at 11 o'clock, I noticed a large spot and nine small ones just coming from the east limb of the sun in about the same latitude as the first spot. The latter was more indistinct and nearer the limb. The coincidence of these spots with the auroral display here is further emphasized by the sudden rising of one of those dry, dessicating winds from the north which are nearly always accompanied by much electric disturbance in the atmosphere. It rose at the hour of the disappearance of the aurora, and blew with great force until 7:30 A. M. In Southern California this wind was very high and did much damage.

FRANK SOULE.

Students' Observatory,
University of California, Dec. 16, 1887.

The eclipse of the moon, January 28, was not observed at Carleton College Observatory. The sky was overcast with thick clouds during its entire period. The disappointment of observers here was somewhat relieved by receiving a cable message from Paris by kindness of Mr. Appel, of Cleveland, saying that the eclipse was splendidly seen at that place.

Any person desirous of disposing of a good second-hand transit instrument, astronomical clock or Chronograph may possibly be assisted in the sale of the same by corresponding with the publisher of this journal.

Errata. I notice two misprints in my article in the January No. of THE MESSENGER. In p 24, line 11 from bottom, "he" should be "we," and line 3 from bottom "$(2.611)^3$" should be "$(2.512)^3$"

W. H. S. MONCK.

National Academy of Sciences. Volume II of the Memoirs of the National Academy of Sciences contains four papers, whose titles are: Report of the Eclipse Expedition to Caroline Island, May, 1883; Experimental Determination of Wave-Lengths in the Invisible Prismatic Spectrum, by Prof. S. P. Langley; On the Subsidence of Particles in Liquids, by Prof. W. H. Brewer; On the Formation of a Deaf Variety of the Human Race, by Prof. Graham Bell.

The first two are themes of great interest to science generally, and each has received careful attention during recent years. The full discussion of Professor Hastings' theory of the solar corona will be read by the mathematician, as well as the student of solar physics, with profit. The volume, as a whole, reflects credit on those in charge of its preparation and the National Academy of Sciences.

The New Spectroscope for Lick Observatory. Some time ago we were informed that the new spectroscope for Lick Observatory had been completed and tested in a preliminary way. Soliciting information from Mr. J. A. Brashear, the maker, of Allegheny City, Pa., he kindly informed us that he had made some observations with it on the solar spectrum, using the fine grating that was ruled by Professor Rowland and that he had never seen the B group so beautifully separated into its components as he saw it in this spectroscope.

Lunar Eclipse at Baltimore. The recent total eclipse of the moon (Jan. 28) was very well observed here. The air was very clear. The illumination during the whole of totality was very considerable, and the moon was very easily seen by the casual observer.

Several small stars were occulted at the end of the total phase, the sunlight came on in beautiful contrast. The refracted light during the total phase seemed to be variable, and was decidedly so in local distribution. J. R. H.

Comet 1887 IV (Barnard May 12). Mr. Frank Muller, of the Leander McCormick Observatory at the University of Virginia, gives notice that he is planning to compute a definitive orbit for Comet 1887 IV, and asks the favor of all unpublished observations as soon as possible.

Professor P. Tacchini, of the Observatory at Rome, has recently favored THE MESSENGER with several volumes of the Memoirs of the Italian Society of Spectroscopy, of which he himself is an honored member.

By kindness of Librarian Lancaster, of the Royal Observatory of Brussels, the Annual for 1888 is received.

Professor Mary W. Whitney has been chosen to supply the place of Professor Maria Mitchel, during the leave of absence of the latter from Vassar College. Miss Whitney has studied at Harvard College Observatory.

We have recently learned, through a friend, of the equipment of an astronomical observatory for Bucknell University at Lewisburg, Pa. Mr. William Bucknell, of Philadelphia, is the generous donor. The observatory has a fine ten-inch Clark equatorial, a Fauth three-inch transit, a Waldo clock and other smaller instruments.

Markings on Mercury. At a late meeting of the Liverpool Astronomical Society, Mr. Denning, of Bristol, presented a paper on the planet Mercury, setting forth particularly studies of surface markings in 1882 especially. These light and dark tracings were so pronounced, as to suggest an analogy to those of the planet Mars. Professor Schiaparelli, of Milan, has made interesting observations of Mercury which seem to confirm those of Mr. Denning.

Pulkowa Observatory. The last *Observatory* has a report of work at Pulkowa during the last year. The transits were 3767, zenith distances, 1130, each involving two observations in reversed positions of the instruments, Professor Struve considering this the most satisfactory method of obtaining fundamental declinations, and preferring the transit circle only for differential measures.

Solar Parallax. We notice in *Bulletin Astronomique* for February, p. 65, an account of the application of a new method of discussion to the results of the Transit of Venus Observations obtained by the French expedition 1874, by M. Obrecht. He obtains for the solar parallax $8.80'' \pm 0.06''$.

Later reports from Professor W. Tempel, of Arcetri, are a little more favorable respecting his health and recovery.

Mr. E. E. Reed, of Camden, N. J., is about to erect an astronomical observatory with a six-inch equatorial. He is a gentleman of fine scientific scholarship, and he proposes to do practical work in astronomy.

---

*Pons-Brooks Comet.** Messrs. Schulhof and Bossert request observers, who have unpublished observations of the Pons-Brooks comet to kindly forward them to the Observatory of Paris.

BOOK NOTICES.

Astronomy for Amateurs, a Practical Manual of Telescopic Research in all Latitudes Adapted to the Powers of Modern Instruments. Edited by John A Westwood Oliver, with the assistance of T. W. Backhouse, J. Rand Capron, W. F. Denning, T. Gwyn Elger, W. Franks, J. E. Gore, Sir Howard Grubb, E. W. Maunder and others. Illustrated. London: Messrs. Longmans, Green & Co., publishers. New York, 15 East Sixteenth Street. 1888; pp. 316.

This book supplies a real need and it will be welcomed by a large class of amateurs in the United States. This class consists mostly of young people who will certainly be helped by a plain statement of practical and useful work that inexperienced observers like most of them may soon learn to do well, who have the aid of small telescopes. This class is large and needs assistance and direction. The preliminary chapter is by the editor, who speaks directly to amateur workers, stating the useful fields of work open to them. These are, the sun, moon, planets, comets, double stars, variable stars, star colors, stellar distribution, zodiacal light, meteors and auroræ.

The chapter on the telescope is written by Sir Howard Grubb, one of the most noted of instrument makers in the world. It covers the ground well. E. W. Maunder, late editor of the *Observatory*, prepared the chapter on the sun, in which is found useful information on the measurement of sun-spots, methods of observing and recording the same, besides other things that the amateurs may do in the study of the sun. The chapter on the moon is presumably by the editor who brings out well the essentials for the young

*Bulletin Astronomique.

observer. The late useful information here given can not fail to interest the professional reader. The field of work chosen will easily hold the attention of the young observer and give him methods of study used by good observers at the present time. A full chapter on the planets appears which was prepared by W. F. Denning, also another on comet-seeking by the same author, who has been favorably known, on both sides of the water, for years, in the study of meteors. Our own Mr. Burnham of Chicago has the honor of contributing the chapter on double stars, rightly enough, if the best living authority on this subject is desired. This chapter is a reprint, with some modifications, of the matter which was published in THE SIDEREAL MESSENGER in numbers 2 and 3 of Vol. I.

The mode of computing the orbits of double stars is by J. E. Gore, who also contributes a valuable chapter on variable stars. W. S. Franks writes the chapter on the star colors, T. W. Backhouse on stellar distribution and J. Rand Caprore that on the auroræ.

The mention of the names of these writers is assurance for something good, and the book is a timely one.

The Essentials of Plain and Spherical Trigonometry. By Webster Wells, S. B., Associate Professor of Mathematics in the Massachusetts Institute of Technology. Messrs. Leach, Shewell & Sanborn, publishers, Boston and New York.

The salient points in this new book to which the attention of teachers should be called are (1) the proofs of functions of 0°, 90°, 180°, 270°. The mode of proof is by rectangular coördinates, and proper at this stage of the student's advancement, because he ought to have used such proofs in infinitesimal analysis in algebra.

2. The functions of negative arcs are carefully explained by figures and proofs clearly obtained.

3. The proofs of the fundamental formulæ for any angle are made to depend on the definitions of the functions, and generalized by the use of rectangular coördinates. Other new points are the discussion of the line values of trigonometric functions of any number of degrees, the proofs of formulæ for sines and cosines, the *ambiguous case* and considerable interest pertaining to the spherical triangle. The new points are generally improvements.

CARLETON COLLEGE.

NORTHFIELD, MINNESOTA.

Full Preparatory and Collegiate Departments.
English, Scientific, Literary and Musical Courses.
All Departments open to Students of Either Sex.
Expenses Very Low.

CALENDAR FOR 1887-8.

Winter Term begins Wednesday, January 4th, and ends March 15th, 1888.
Term Examinations, March 14th and 15th, 1888.
Spring Term begins Wednesday, March 28th and ends June 14th, 1888.
Term Examinations, June 12th and 13th, 1888.
Examinations to enter College, June 9th and 11th, and September 4th, 1888.
Anniversary Exercises, June 10th–14th, 1888.
Wednesday, September 5th, 1888, Fall Term begins.

JAMES W. STRONG, President,
NORTHFIELD, MINN.

VICK'S FLORAL GUIDE.

A silver lining to every cloud! With the short, dull days of early winter come the cheery holidays and Vick's beautiful annual, and lo! spring already appears not far distant. We can almost see the greening grass and the blooming flowers. In the way of Catalogue, Vick's Floral Guide is unequaled in artistic appearance, and the edition of each year that appears simply perfect, is surpassed the next. New and beautiful engravings and three colored plates of flowers, vegetables and grain are features for 1888. Its lavender tinted cover, with original designs of most pleasing effects, will ensure it a prominent place in the household and library. It is in itself a treatise on horticulture, and is adapted to the wants of all who are interested in the garden or house plants. It describes the rarest flowers and the choicest vegetables. If you want to know anything about the garden, see Vick's Floral Guide, price only 10 cents, including a Certificate good for 10 cents worth of seeds. Published by James Vick, Seedsman, Rochester, N. Y.

For Sale. A very fine, short focus, 4½-inch Equatorial, by John Clacy, of Boston. Address for particulars,
JOHN JACKSON,
21 Worcester Square, Boston, Mass.

For Sale, AT A BARGAIN—An Equatorially mounted Telescope, with 4-inch objective, zenith prism, three eye pieces, sun glass, and star finder, all in first class condition. Address
T. H. BRESNAHAN,
No. 99 Porter St., Detroit, Mich.

For Sale. A second-hand Sextant, by Spencer Browning, London. In fine condition, 7½-in. arc, divided on silver, reading to ten seconds. Also smaller Sextant, Aneroid Barometers, etc. For sale cheap. Address
B. F. GROAT.
151 Summit Ave., St. Paul, Minn.

Minneapolis & St. Louis Railway

AND THE FAMOUS

ALBERT LEA ROUTE.

TWO THROUGH TRAINS DAILY

From St. Paul and Minneapolis to Chicago

Without change connecting with the fast trains of all lines to the

EAST AND SOUTHEAST.

The direct and only line running through cars between Minneapolis and Des Moines, Iowa, via Albert Lea and Fort Dodge.

Solid Through Trains between Minneapolis and St. Louis and the principal cities of the Mississippi Valley, connecting in Union depot for all points South and Southwest.

Many hours saved and the only line running two trains daily to Kansas City, Leavenworth and Atchison, making connections with the Union Pacific and Atchison, Topeka and Sante Fe Railways.

Close connections made in Union depot with all trains of the St. Paul, Minneapolis and Manitoba, Northern Pacific, St. Paul & Duluth Railways, from and to all points north and northwest.

Remember the trains of the Minneapolis & St. Louis Railway are composed of comfortable day coaches, magnificent Pullman sleeping cars, Horton reclining chair cars, and our justly celebrated palace dining cars.

One hundred and fifty pounds of baggage checked free. Fare always as low as the lowest. For time tables, through tickets, etc., call upon the nearest ticket agent, or write to

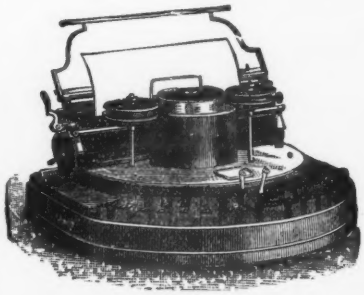
S. F. BOYD, General Ticket Agent,

MINNEAPOLIS, MINN.

THE HAMMOND TYPE-WRITER.

Highest Awards at London, New York and New Orleans.

Send for Catalogue —AND— Specimen of Work.



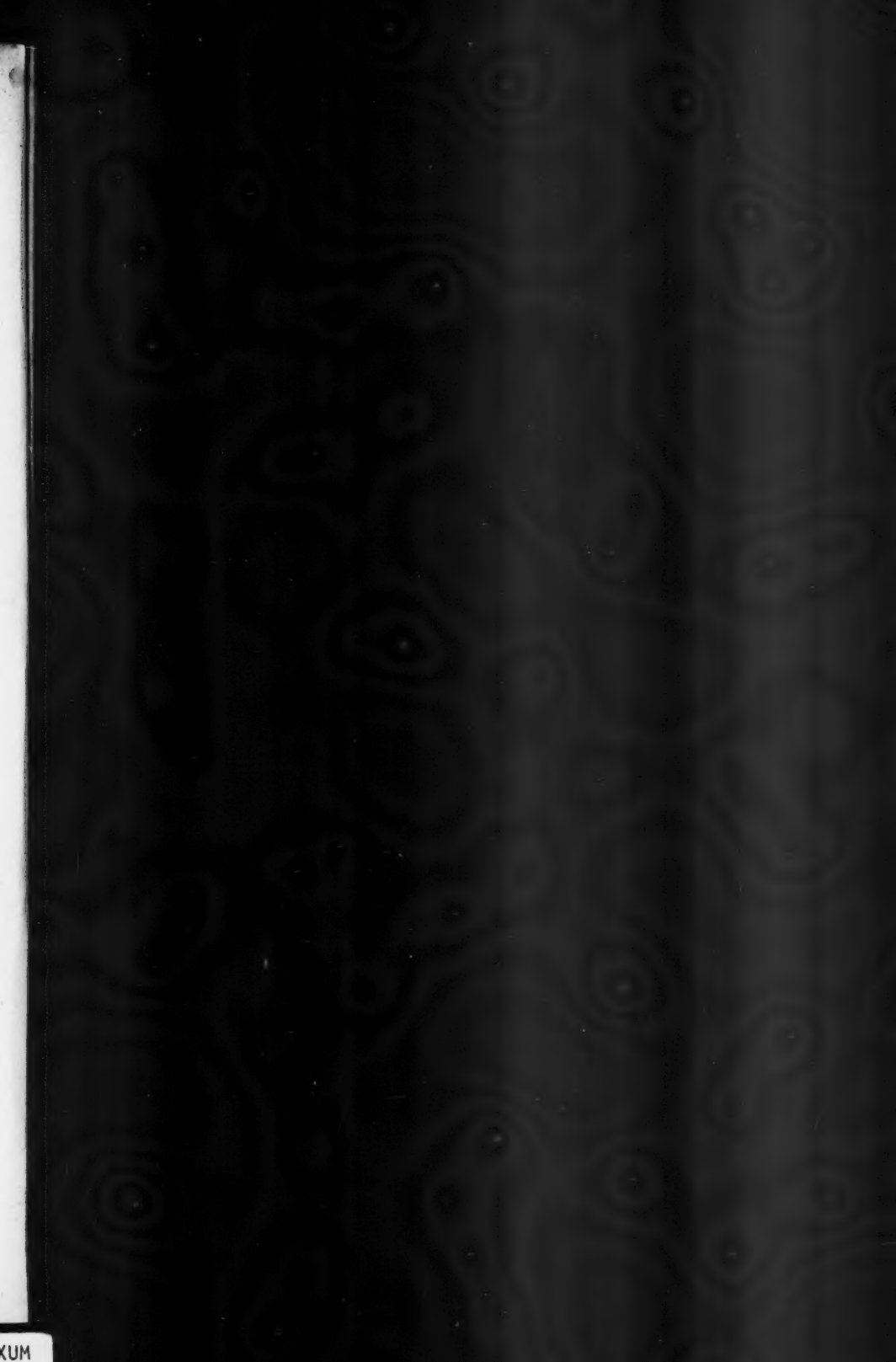
Unparalled Speed, Perfect Alignment, Uniform Impression, Changeable Type, Greatest Range of Work, Simplicity and Durability of Mechanism, Ease of Manipulation, Portability, Beauty.

Among those who are using the Hammond in Minnesota are Professor W. W. Payne Carleton College, Northfield; W. J. Dyer & Bros., music dealers, Minneapolis; Bradbury & Hall, commission, Minneapolis; Archibald's Business College, Minneapolis; C., St. P., M. & O. Railway, St. Paul (two machines); John Y. Hooper, stenographer, 8th district, Belle Plaine; Duluth Life Association, Duluth; H. F. Williams, state secretary, Y. M. C. A.

Machines will be placed on trial with responsible parties.

The Hammond Type-Writer Co.,
77 Nassau Street, New York.

Heath & Kimball, State Agents,
14 Fourth Street South, Minneapolis

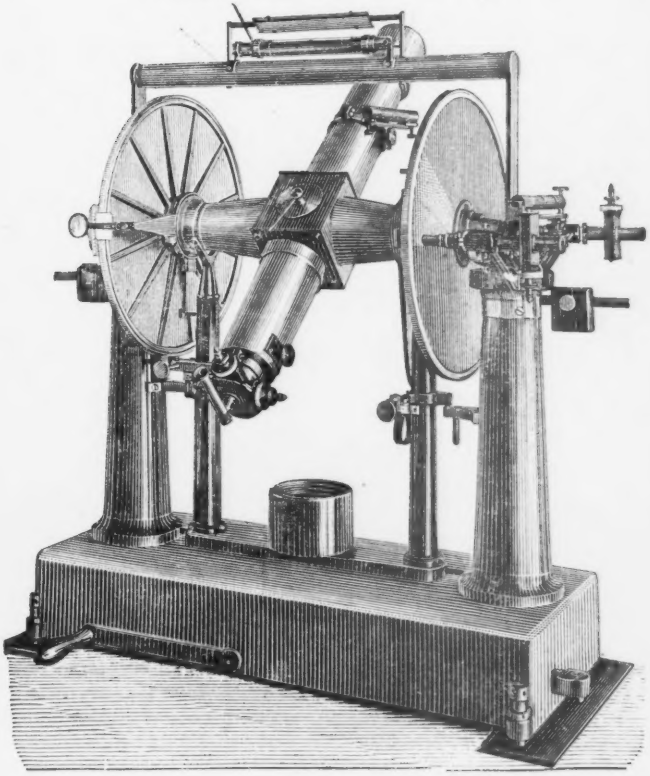


XUM

FAUTH & CO.,

Astronomical Works,

WASHINGTON, D. C.



TRANSIT CIRCLE—4 inch objective. 16 inch circles.

EQUATORIALS, TRANSITS, MERIDIAN CIRCLES,

Astronomical Clocks with Break-Circuit Arrangement,

Chronographs, Level Vials reading to single seconds, Eye Pieces of all kinds, Micrometers, Spectroscopes, and Astronomical Outfits of every kind. Also all kinds of instruments for higher Geodesy and Engineering purposes.

SEND FOR NEW CATALOGUE.

WARNER & SWASEY,

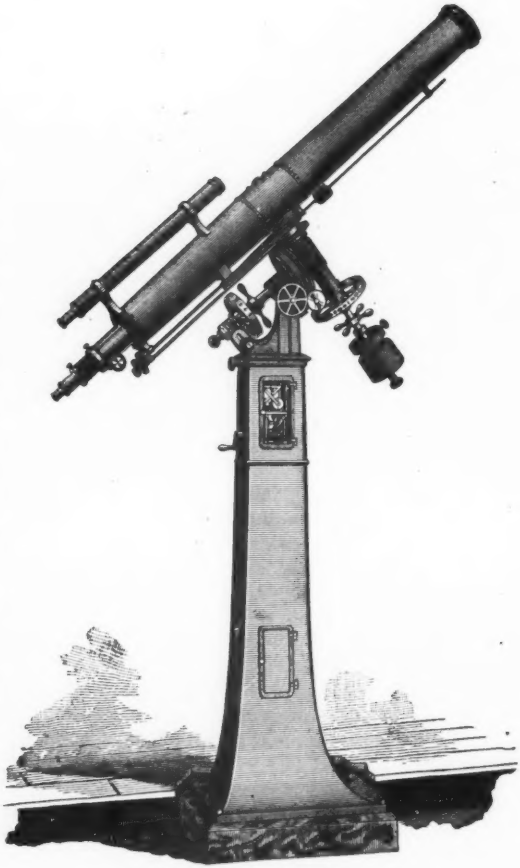
MANUFACTURERS OF

OBSERVATORY OUTFITS,

OBSERVATORY DOMES OF ALL SIZES,

With Patent Frictionless Mechanism for Running Gear and Shutters.

TRANSIT INSTRUMENTS, CHRONOGRAPHS, &C.



6-INCH EQUATORIAL.

EQUATORIAL TELESCOPES,

From 6-inch aperture to the largest size.

WARNER & SWASEY, CLEVELAND, OHIO, U. S. A.